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Europäisches Patentamt  
European Patent Office  
Office européen des brevets

(11) - Publication number:

**0 201 331**  
**A2**

(12)

# EUROPEAN PATENT APPLICATION

(21) Application number: 86303487.2

(22) Date of filing: 08.05.86

(51) Int. Cl.: **B 29 C 61/00, C 08 J 5/18,**  
**C 08 L 23/08, C 08 L 23/16**  
**// B29K23:00, B32B25:08,**  
**B32B31:30**

(30) Priority: 08.05.85 US 732127

(43) Date of publication of application: 12.11.86  
Bulletin 86/46

(84) Designated Contracting States: BE DE FR GB IT NL SE

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(54) Oriented elastomeric film and method of manufacture.

(57) An oriented thermoplastic elastomer comprising an elastomer, EVA, and process oil is prepared by stretch orienting the film at an elevated temperature and annealing the film to freeze in stresses and strains in the film. In one embodiment, the thermoplastic elastomer is provided with a thin coating of a thermoplastic to provide nonblocking.

**EP 0 201 331 A2**

1 Oriented Elastomeric Film and Method of Manufacture

2 This invention relates generally to ~~the~~ thermoplastic elasto-  
3 mers and in particular, to ~~the~~ thermoplastic elastomers<sup>films</sup> which have  
4 been thermally oriented.

5 Thermoplastic elastomers possess properties of both thermo-  
6 plastics and elastomers and have a wide range of applications. In  
7 certain applications, a thermoplastic elastomer film is dimensionally  
8 stabilized in a stretched condition (wherein stresses and strains in  
9 the film have been frozen in) for subsequent use. For example, the  
10 stretched thermoplastic elastomer may be applied to a substrate and  
11 later heated causing the thermoplastic elastomer to shrink and retain  
12 substantial elastic properties. One such use is disclosed in European  
13 ~~Patent Application No. 84301717.9~~ (Publication <sup>EP-A-</sup>Number 0119815) wherein  
14 the stretched dimensionally stable thermoplastic elastomer is placed  
15 on a diaper waistband and reheated causing the thermoplastic elastomer  
16 to contract and revert to a heat stable elastic state. The diaper  
17 thus is provided with a flexible and stretchable waistband. A  
18 similar application of thermoplastic elastomers is disclosed in  
19 ~~European Patent Application No. 84301720.38~~ (Publication <sup>EP-A-</sup>Number  
20 /0119827). These publications are cited merely to disclose a possible  
21 use of thermoplastic elastomers.

22 In many applications, particularly where the thermoplastic  
23 elastomer is secured to a substrate for later contraction by the  
24 application of heat, it is important that the thermoplastic elastomer  
25 have relatively high shrink force since the substrate resists shrink-  
26 age. The shrink force is determined by measuring the shrinkage of the  
27 film sample against an applied force and is referred to herein as  
28 weighted shrink. The weighted shrink properties differ markedly from  
29 free shrinkage (no applied weight) and hence is a key property in  
30 determining the suitability of a heat shrinkable film on substrates.

31 U.S. Patent 4,303,571, issued to D. S. Jansen et al/ disclose  
32 a thermoplastic elastomer film comprising 25 to 55 parts by weight of  
33 an ethylene-propylene copolymer, 35 to 55 parts by weight of an EVA  
34 copolymer and 15 to 25 parts by weight of a liquid hydrocarbon process  
35 oil. Such film may be oriented, in which  
state it is dimensionally stable and thermally  
unstable, being contractible to a thermally stable  
and elastic condition by application of heat.

and its equivalent  
EP-A-0032804

As will be demonstrated in the discussion of the comparative examples contained herein, the elastomeric film made from the composition disclosed in U.S. Patent <sup>US-A</sup> No. 4,303,571 possesses satisfactory shrink properties, but not nearly as good as those possessed by the composition of the present invention, particularly with respect to weighted shrink properties.

A problem associated with thermoplastic elastomers is tackiness which impedes unwinding of the film during processing. This is a particularly serious problem with film compositions containing EVA and processing oil. Moreover, addition of particulate antiblocks are not particularly effective in thermoplastic elastomers because of the difficulty in dispersing the additives uniformly on the film surface, since the additives tend to concentrate in the elastomer phase.

#### SUMMARY OF THE INVENTION

The present invention provides an improved film composition and process for manufacturing which exhibits excellent shrink force and possesses nonblocking properties.

*As mentioned above, the* ~~The~~ film composition in one embodiment of the present invention comprises from 10 to 40 weight percent of an olefinic elastomer, not more than 12 weight percent (preferably not more than 10 weight percent) of a normal liquid processing oil, and from 50 to 80 weight percent of a thermoplastic ethylene copolymer, preferably vinyl acetate copolymer (EVA), all weight percents based on the weight of the three component composition. The film is dimensionally stable in a stretched condition (draw ratio of 1.3:1 to 6:1) and is contractible to a thermally stable and elastic condition by the application of heat.

The method for preparing the thermoplastic elastomer film comprises stretching the film at a temperature below the melting point of the EVA component at a draw ratio between about 1.3:1 and 6:1, annealing the stretched film, and cooling of the film to ambient temperature. The film may be used by securing it to a substrate such as an inelastic thermoplastic or fabric, and heating the film to an elevated temperature whereby the film contracts to a thermally stable length and possesses elastic properties. The composite thus may be expanded by the application of tension which upon release returns to its original shape.

<insert page 2c>

<insert page 2d>

1 In another embodiment of the invention, the film comprises a  
 2 composite of one layer of a thermoplastic elastomer and a thin coating  
 3 of an ethylene polymer or copolymer having a relatively high Melt  
 4 Index. Upon the subsequent stretch orienting the composite, the  
 5 coating becomes even thinner. The thermoplastic elastomer layer is  
 6 ~~preferably~~ the composition as defined above, <sup>confering</sup> ~~particularly~~ <sup>in</sup> high  
 7 shrink force ~~(is desired)~~ in addition to antiblock properties. The  
 8 coating preferably also contains particulate antiblock additives, thus  
 9 avoiding the difficult problem of distributing antiblock particles on  
 10 or near the film surface. ~~It will therefore be appreciated that the~~ <sup>←→</sup> ~~present invention~~ <sup>confering</sup> ~~contemplates~~ <sup>process for</sup> (1) an improved stretch-  
 11 oriented, dimensionally stable thermoplastic elastomer <sup>film</sup> which is  
 12 shrinkable upon application of heat, (2) a composite of the thermo-  
 13 plastic elastomer <sup>film</sup> and a substrate wherein the orientation has been  
 14 released by the application of heat, (3) a <sup>method</sup> ~~process for~~ of preparing the  
 15 oriented thermoplastic elastomer film, <sup>and</sup> (4) a method of manufacturing  
 16 an elastic composite comprising a thermoplastic elastomer <sup>film</sup> and a sub-  
 17 strate of inelastic material. ~~(5) a thermoplastic elastomer having a~~  
 18 ~~thin coating of a nonblocking polymer and (6) a method of preparing a~~  
 19 ~~nonblocking thermoplastic elastomer.~~  
 20

# 21 DESCRIPTION OF THE PREFERRED EMBODIMENTS

22 In describing the present invention, it is necessary to use  
 23 certain technical terms, some of which are commonly used in the indus-  
 24 try and others of which are defined herein to express a concept.

25 In order to avoid confusion, the following terms used herein  
 26 shall have the meaning indicated:

27 "Draw ratio" - the ratio of the final stabilized length  
 28 (after orientation and "snapback") of an oriented film and  
 29 the initial length of the film before orientation. Draw  
 30 ratio in unidirectional orientation is also equal to the  
 31 ratio of the thickness of the stabilized oriented film and  
 32 the initial unoriented film.

33 "Shrink force" - the force required to prevent shrinkage of  
 34 an oriented film by application of heat.

35 "Shrink stress" - the shrink force per unit area ( $\text{g/cm}^2$ ).

36 "Annealing" - a heat treatment process for reducing strains  
 37 and stresses set up in the film during orientation. The  
 38 process comprises maintaining the film while in stretched

ent)

in (a)  
film is

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condition at the annealing temperature, for a period of 1me, followed by cooling the film to room temperature.

"Thermoplastic elastomer" - frequently called rubbery thermoplastics, are blends of a thermoplastic material and elastomer that are processable as a melt, at elevated temperatures, but exhibit properties similar to vulcanized elastomers at room temperature.

"Melt Index" (MI) - g/10 min (ASTM-D 1238; condition E).

In its broadest form, the thermoplastic elastomer film composition of the present invention comprises three main components, (1) olefinic elastomer, (2) ethylene copolymer and (3) a hydrocarbon process oil.

The concentrations of the three components of the blend are as follows:

<u>Component</u>	<u>Concentration</u>	<u>- Preferred Concentration</u>	<u>Most Preferred</u>
Olefinic Elastomer	10-40 wt %	15-30 wt %	20-30 wt %
Ethylene Copolymer	50-80 wt %	60-80 wt %	65-75 wt %
Process Oil	<i>not more than</i> 12 wt %	2-10 wt %	4-8 wt %

The above concentration range may be combined in any permissible combination, although the particular combinations shown are preferred. For example, a preferred composition comprises 10-40 wt % elastomer, 60-80 wt % ethylene copolymer, and *not more than* 12 wt % process oil. The weight concentration of each component is based on the total weight of the three main components.

Elastomer Component: The olefinic elastomer component of the composition preferably comprises an ethylene copolymer elastomer, such as a copolymer of ethylene with higher alpha-olefin. Preferred ethylene elastomer copolymers include EPM (ASTM D-1418-72a designation for an ethylene-propylene elastomer copolymer) or EPDM (ASTM D-1418-72a designation for an ethylene-propylene diene elastomer terpolymer). Also usable are high molecular weight polyisobutylene, butyl rubbers and halogenated butyl rubbers.

Preferred ethylene elastomer copolymers for use herein comprise from 30 to 90 weight percent ethylene, more preferably from 35 to 80 weight percent ethylene, and most preferably from 50 to 80 weight percent ethylene and have a Mooney viscosity (ML 1+8 at 127° C) between 25 and 80.

1 EPDM is a terpolymer of ethylene, a higher alpha-olefin such  
2 as propylene, and a nonconjugated diene. In such elastomers, the  
3 nonconjugated diolefin may be straight chain, branched chain or cyclic  
4 hydrocarbon diolefins having from 6 to 15 carbon atoms.

5 Of the nonconjugated dienes typically used to prepare these  
6 copolymers, preferred are dicyclopentadiene, 1,4-hexadiene, 5-methy-  
7 lene-2-norbornene and 5-ethylidene-2-norbornene; 5-ethylidene-2-  
8 norbornene (ENB) and 1,4-hexadiene are particularly preferred diole-  
9 fins. EPDM elastomers and their method of manufacture are well known  
10 to those skilled in the art. Oil extended EPDM elastomers may also be  
11 used. Preferred EPDM elastomers contain from 30 to 90 weight percent  
12 ethylene and most preferably from 50 to 80 weight percent ethylene,  
13 and from 0.5 to 15 weight percent of the nonconjugated diolefin.

14 As mentioned above, the olefinic elastomer useful in this  
15 invention may also be a polyisobutylene, a copolymer of isobutylene  
16 and isoprene (generally known as butyl rubber) or a halogenated co-  
17 polymer of isobutylene and isoprene (generally known as halogenated  
18 butyl rubber, such as chlorinated, brominated and chlorobrominated  
19 butyl rubber). Butyl rubber is a vulcanizable rubber copolymer con-  
20 taining from 85 to 99.5 percent combined isoolefin having from 4 to 8  
21 carbon atoms and from 0.5 to 15 percent combined conjugated diolefin  
22 having from 4 to 8 carbon atoms. Such copolymers and their prepara-  
23 tion are well known, and generally the isoolefin is a compound such as  
24 isobutylene and the diolefin is a compound such as butadiene or iso-  
25 prene. Halogenated butyl rubbers are also well known: chlorinated  
26 and brominated butyl rubber generally contains from 1.0 to 3.0 weight  
27 percent bromine and from 0.05 to 0.5 weight percent chlorine.

28 Ethylene Copolymer Component: The ethylene copolymers  
29 include those of ethylene and alpha-olefins having 3 to 16 carbon  
30 atoms such as propylene or 1-butene. Also included are copolymers of  
31 ethylene with unsaturated esters of a lower carboxylic acid or with an  
32 unsaturated carboxylic acid. In particular, copolymers of ethylene  
33 with vinyl acetate (EVA), or with acrylic acid (EAA), or methacrylic  
34 acid (EMA), are preferred. The ethylene copolymers to be employed  
35 generally contain from 50 to 99 weight percent ethylene, most  
36 preferably from 60 to 95 weight percent ethylene.

1 The most preferred ethylene copolymer useful in the present  
2 invention is EVA. The EVA may have a vinyl acetate (VA) content  
3 between about 9% and 40% by weight, with about 15 to 35 weight percent  
4 VA being preferred.

5 VA contents below about 9 wt % do not possess sufficient  
6 flexibility and orientability for purposes of the present invention  
7 and VA contents above 40 wt % exhibit excessive tackiness. The best  
8 balance of orientability and non-tackiness occurs at VA contents  
9 between 15 and 35 wt %.

10 Preferred Melt Index (ASTM-D-1238, Condition E) for EVA is  
11 from 1 to 20, with 2 to 10 being most preferred.

12 The ethylene copolymer component normally will determine the  
13 operating temperatures of the tentering and annealing operations.  
14 These operations may be carried out at temperatures not less than  
15 100°F/ <sup>(37.7°C)</sup> and below (preferably not more than 5.6°C below) the crystalline  
16 melting point of the ethylene copolymer component. The annealing step  
17 preferably is at  $\pm 11.1^{\circ}\text{C}$  of the orienting temperature. The crystalline  
18 melting point of EVA ranges from approximately  $40^{\circ}\text{C}$  to  $94^{\circ}\text{C}$ ,  
19 depending on the VA content and MI, with the preferred EVA's having  
20 crystalline melting points between about  $54^{\circ}\text{C}$  and  $71^{\circ}\text{C}$ . For  
21 economics, orienting temperatures of  $71^{\circ}\text{C}$  and below are preferred.

22 Process Oil Component: Hydrocarbon oils useful in the  
23 present invention function as process aids whose activity is enhanced  
24 in the presence of vinyl acetate copolymers, as plasticizers producing  
25 low modulus and enhanced elasticity in the solid state and those  
26 useful are the normally liquid hydrocarbon processing and extender  
27 oils (ASTM D 2226) categorized as aromatic, highly aromatic, naph-  
28 thenic and paraffinic process oils of a medium viscosity range. Oils  
29 sold under the trademarks "Flexon" and "Sunpar" have been found  
30 especially useful.

31 Other Additives: The composition may also include a filler  
32 material, an antiblock agent, processing aids, stabilizers and other  
33 conventional additives.

#### 34 FILM PREPARATION

35 Resin/Blend Preparation: Preparation of compositions usable  
36 in this invention can be achieved in several different ways. The  
37 various components may be brought into intimate contact by, for ex-  
38 ample, dry blending these materials and then passing the overall

and in

which is



1 composition through a compounding extruder. Alternatively, the com-  
2 ponents may be fed directly to a mixing device such as a compounding  
3 extruder, high shear continuous mixer, two roll mill or an internal  
4 mixer such as a Banbury mixer. The optional ingredients previously  
5 described can be added to the composition during this mixing opera-  
6 tion. Overall, the objective is to obtain a uniform dispersion of all  
7 ingredients and this is readily achieved by inducing sufficient shear  
8 and heat to cause the plastics component(s) to melt. However, time  
9 and temperature of mixing should be controlled as is normally done by  
10 one skilled in the art so as to avoid molecular weight degradation.

11 Film Extrusion: Film from the resin compound may be manufac-  
12 tured by conventional tubular extrusion, (blown bubble process) or by  
13 cast extrusion, with the latter being preferred. In the cast extru-  
14 sion process, the molten resin is extruded from an elongate die to the  
15 form of a web. The web is cast onto a chill roller, which solidifies  
16 the polymer, and finally wound into a roll.

17 The extrusion temperatures, die temperatures, and chill roll  
18 temperatures will depend on the composition employed, but generally  
19 will be in the following ranges for the compositions of the present  
20 invention prepared by cast extrusion:

21	Melt Temperature (°F)	350-450	(°C)	176-233
22	Die Temperature (°F)	350-450	(°C)	176-233
23	Chill Roll Temperature (°F)	70-130	(°C)	21-55

24 The process described above may also include a set of embossing rolls  
25 to chill and form the film.

26 Orientation: Orientation of the film may be carried out in  
27 the machine direction (MD) or the transverse direction (TD) or both  
28 directions (biaxially) using conventional equipment and processes.

29 For orientation in the MD, a polymeric film at an elevated  
30 temperature (but below the crystalline melting point of the polymer)  
31 is passed from a feed roll of film around two rollers driven at dif-  
32 ferent surface speeds and finally to a takeup roller. The driven  
33 roller closest to the takeup roll is driven faster than the driven  
34 roller closest to the feed roll, such that the film is stretched  
35 between the driven rollers. The assembly may include a roller inter-  
36 mediate the second roller and takeup roller to cool the film. The  
37 second roller and the takeup roller may be driven at the same peri-

1 pheral speeds to maintain the film in the stretched condition. If  
2 supplementary cooling is not used, the film will cool to ambient  
3 temperature on the take up roll.

4 The degree of stretch will depend upon the relative peri-  
5 pheral speeds of the driven rollers and the distance between the  
6 rollers. Stretch rates of 50 to 500 percent/minute will be satisfac-  
7 tory for most MD orientation applications.

8 Preferably, however, film orientation will be carried out in  
9 a tentering device to impart TD orientation to the film. The film is  
10 cast as described above or is unwound from a film roll and then  
11 gripped by the edges for processing through the orientation steps.  
12 The film is passed successively through a preheat step, a stretching  
13 step at elevated temperatures (e.g. from 37.7° C to a temperature  
14 slightly below the crystalline melting point of the ethylene  
15 copolymer), an annealing step, and finally a cooling step. (Although  
16 cooling may be considered part of the annealing step, for convenience  
17 it is described as a separate step herein.) The preheat, orientation,  
18 and a portion of the annealing temperature is controlled at an  
19 elevated temperature but below the crystalline melting point of the  
20 polymer. Although not essential, it is preferred that tension be  
21 maintained on the film during the annealing and cooling steps to  
22 minimize shrinkback. Upon cooling to ambient temperature (i.e., room  
23 temperature) or near ambient, the holding force may be released. The  
24 film may contract somewhat (snapback) in the TD but will retain  
25 substantial portion of its stretched length.

26 The tenter operating conditions can vary within relatively  
27 wide ranges and will depend on the several variables including film  
28 composition, film thickness, degree of orientation desired, annealing  
29 conditions, etc. The following is exemplary of a process for stretch-  
30 ing 100 micron thick film (containing EVA) from 61 cm wide to a  
31 final width of about 152 cm, using a tenter manufactured by  
32 Marshall and Williams Company of Providence, Rhode Island.

ESTIMATED FILM RANGE

1	2	3	4	5	6	7
		Step	Broad	Preferred	Typical	Approximate Time (Sec)
4	Preheat		100-160°F 37.7-71°C	115-140°F 46-60°C	125°F 51.6°C	3.0
5	Stretching		100-160°F 37.7-71°C	115-140°F 46-60°C	125°F 51.6°C	9.0
6	Annealing		100-160°F 37.7-71°C	110-150°F 43-66°C	120°F 48.8°C	3.0
7	Cooling		Ambient	Ambient	Ambient	6.0

8 As indicated earlier, it is highly desirable to employ an  
 9 annealing step in the process. Annealing partially relieves the  
 10 internal stress in the stretched film and dimensionally stabilizes the  
 11 film for storage. It has been found that by annealing the film at a  
 12 temperature of  $\pm 22.2^{\circ}\text{C}$ , preferably  $\pm 11.1^{\circ}\text{C}$  of the orientation tempera-  
 13 ture (but slightly below the crystalline melting point of the ethylene  
 14 copolymer) eliminates undesirable shrinkage during storage. The  
 15 preferred annealing temperature is between  $110^{\circ}\text{F}$  and  $130^{\circ}\text{F}$  <sup>(43.3°C) (54.4°C)</sup> Tempera-  
 16 tures which result in excessive stress relieving should be avoided,  
 17 since substantial frozen in stresses and strains should remain after  
 18 the process is completed.

19 Annealing can be accomplished by maintaining the film in the  
 20 stretched condition at the annealing temperature. Preferably, how-  
 21 ever, the annealing and cooling is carried out while permitting the  
 22 film to contract slightly, but still under stress. The guide rails of  
 23 the tenter can be arranged in a converging manner to provide the an-  
 24 nealing and cooling while the film contracts. The controlled shrink-  
 25 back of from 5 to 30%, preferably between 15 and 25%, of the maximum  
 26 stretched width has given particularly good results in eliminating  
 27 storage shrinkage. This annealing and preshrinking removes some of  
 28 the film stresses and strains so that shrinkage will not occur at  
 29 storage temperature. However, the annealing and cooling does not  
 30 remove all the frozen in stress, and strain, since upon heating to  
 31 elevated temperatures above storage temperature the film will shrink.

32 The degree of stretching may vary within wide ranges. Draw  
 33 ratios of 1.3:1 to 6:1 are possible with 2:1 to 4:1 being preferred  
 34 for TD tentering. The actual stretching will occur at higher ratios  
 35 (1:5 to 9:1) to allow for controlled shrinkage and snapback.

EXAMPLES

In order to demonstrate the effectiveness of the present invention, particularly in respect of improved shrink force and non-blocking properties, a series of experiments were conducted comparing performance of the film of the present invention with that of the prior art (~~U.S. Patent No. 4,303,571~~ <sup>US-A-</sup> and its equivalent EP-A-0032804).

Film Samples:

Samples having the compositions listed in Table I were prepared by blending the components in the weight concentrations indicated using a Banbury mixer. Each composition also included 6 wt % ethylene acrylic acid copolymer and filler material ( $\text{CaCO}_3$ ). The resin blend was cast extruded into 150 micron (approx.) thick film using 7.6 cm extruder and 76.2 cm wide flat die.

Properties of the Film:

Each film sample was then tested for orientation/shrinkage properties with an Instron (Model 1122) in a temperature controlled chamber. 2.5 cm wide strips (cut in the TD) were taken from each sample, marked with lines 4 cm apart and then drawn to 9 cm at 10 cm/minute at an elevated temperature ( $60^\circ\text{C}$  and  $63^\circ\text{C}$ ). After orientation, each stretched film was quenched with water and removed from the Instron. Six film strips were drawn for each formulation and the test was run in random order in blocks of nine to eliminate systematic test error.

For each formulation, 6 strips were heated in the oven for three minutes at  $65.5^\circ\text{C}$ ; three strips with a fixed weight and the other three strips freely suspended. The film strips were removed from the oven, allowed to cool and then measured to determine the % recovery.

The % recovery was calculated by the following formula:

$$\text{Percent Recovery} = \frac{\text{Initial length}^* - \text{Final length}^{**}}{\text{Initial length}^* - 4 \text{ cm}} \times 100$$

\* Initial stretched length (cm) after "snapback". ( $65.5^\circ\text{C}$ )

\*\* Final length (cm) after full shrinkage at  $150^\circ\text{F}$  in oven.

Table II presents the results, comparing the three sample average for each formulation of the present invention (Samples A, B and C) with the three sample average of each formulation of the prior art (Samples D, E and F).

1 As revealed in Table II, the percent recovery under re-  
 2 strained conditions Samples A, B and C was higher than that of Samples  
 3 D, E, and F. Percent restrained recovery for the A, B, C sample group  
 4 averaged 86.4%, whereas that of D, E F group averaged 82.3%. The  
 5 shrink force, which is the force required to keep the film from  
 6 shrinking can be calculated from these data. As shown in Table II,  
 7 the shrink force for Samples A, B and C was substantially higher than  
 8 that for Samples D, E, and F. Samples A and B exhibited particularly  
 9 improved shrink force.

10 The higher shrink force of the Samples A, B and C permits use  
 11 of a thinner gauge film at the same draw ratio as demonstrated by the  
 12 following experiments.

13 Additional experiments were conducted to demonstrate shrink-  
 14 age as a function of restraining force and shrinkage temperature. Two  
 15 oriented films having the compositions of Samples A and D were pre-  
 16 pared using a Marshall and Williams Tenter operated under typical  
 17 conditions described in the Orientation section hereof. Each film  
 18 thus was processed as follows:

	<u>Sample A</u>	<u>Sample D</u>
20 Initial Length	( 22.5 inches ) 57.15cm	(22.5 inches) 57.15cm
21 Stretch Length	(66 inches) 168cm	(66 inches) 168cm
22 Controlled Shrinkback		
23 Length	(60 inches) 152cm	(60 inches) 152 cm
24 Final Stabilized Length	(50 inches) 127cm	50 inches) 127 cm
25 Film Gauge (Initial)	102 microns (avg)	146 microns (avg)
26 Film Gauge (Final)	42 microns (avg)	58 microns (avg)
27 Draw Ratio (Initial Film		
28 Gauge/Final Film Gauge)	2.42	2.51

30 Strips (three for each test) of each film sample were taken  
 31 and subjected to shrinkage in an oven at a controlled temperature  
 32 (49°C or 65.5°C) and at the following restraining forces: 0, 12g, 24g,  
 33 48 g and 60 g. Each strip was permitted to shrink for three  
 34 minutes. Table III presents the three-strip average for each test.  
 35 These data demonstrate that the shrink stress for the composition of  
 36 the present invention was substantially higher than the composition of  
 37 the prior art. Moreover, the shrink force for Sample A strips

exhibited substantially higher shrink force than the Sample D strips, even though the latter strips were substantially thicker in gauge (and hence larger cross sectional area) than the former strips.

It is preferred that the thermoplastic elastomer film on the present invention have a shrink stress of at least 5,000 g/cm<sup>2</sup> at the orientation temperature, thereby providing sufficient force for its intended purpose. It is also preferred that the shrink force at 65.5°C be at least 5,000 g/cm<sup>2</sup>.

It is interesting to note from the Table III data that the shrinkage is generally linear with respect to the applied force. This permits calculating the shrink force and shrink stress. Note that the shrink temperature of 65.5°C is higher than the orientation temperature and 49°C is lower than that temperature. The higher temperature results in more shrinkage since more stresses are relieved.

#### Antiblock Properties

The composition of the present invention also exhibits good antiblocking properties in comparison to films of the compositions of samples D, E and F.

Multi-layers of each film Sample A, B, C, D, E and F compositions (150 micron thick unoriented) were stored for several weeks. The films were then manually separated and subjectively rated for blocking (i.e., resistance to unwinding).

<u>Sample</u>	<u>Observed Blocking</u>
A	No blocking
B	Slight tackiness
C	No blocking
D	Fully Blocked
E	Partial Blocking
F	Partial Blocking

Antiblock property is important in unwinding the film during tentering or during unwinding the oriented film of use. Sticking of the film is undesirable since it slows down the operation or renders the process inoperable.

#### Film

#### THERMOPLASTIC ELASTOMER WITH COATING

Another embodiment of the present invention is directed specifically at solving blocking associated with thermoplastic elastomers, particularly those containing process oil and for high VA, ethylene vinyl acetate. These films are tacky by nature and require

1 antiblock agents such as particulate silica. The elastomer present in  
2 these blends appears to prevent uniform distribution of particulate  
3 antiblock in the resin with the result that the antiblock does not  
4 become uniformly distributed on the film surface.

5 In one aspect of this invention, a thin coating of an ethy-  
6 lene polymer or copolymer is provided on one or both sides of the base  
7 thermoplastic elastomer (core). The subsequent stretching of the film  
8 further reduces the thickness of the coating. The coating thickness  
9 ratio (final/initial) is in proportion to the draw ratio. Preferably  
10 the coating comprises conventional low density polyethylene (LDPE)  
11 having a high Melt Index (in excess of 3.0). Other ethylene polymers  
12 and copolymers that may be used as the coating include linear low  
13 density polyethylenes (LLDPE), EVA, etc. These materials should have  
14 relatively high Melt Indices (in excess of 3.0, preferably 5.0-30.0)  
15 and should be capable of high draw down, making them suitable for  
16 coextrusion with the base resin (core layer), and should possess non-  
17 tacky properties or be treatable to a nontacky condition (e.g.  
18 addition of antiblock). Coextrusion is the preferred coating method,  
19 but extrusion coating may also be used.

20 It is essential that the coating be sufficiently thin to  
21 avoid interference with the shrink and elastic properties of the  
22 thermoplastic elastomer but sufficiently thick to impart antiblock  
23 properties to the composite. This latter requirement means that the  
24 coating must be capable of carrying uniformly distributed therein  
25 particulate finely divided antiblock agent.

26 As applied to the core or base resin, the coating will com-  
27 prise between 2 to 15, preferably 2 to 10 weight percent of the com-  
28 posite and not more than 25 microns thick. Following the orientation,  
29 the coating will be reduced to a thickness of not more than 7 microns  
30 and as thin as possible. Preferred thickness after orientation is  
31 between 1 and 5 microns.

32 The amount of antiblock in the coating may range from 500 to  
33 5,000 ppm, with 1,000 to 4,000 being preferred. The coating may also  
34 include slip agents such as erucamide and oleamide.

35 The coating may be applied to only one side of the base resin  
36 but preferably is applied to both sides.

1 It should be noted that the invention comprising the coating  
2 embodiment is not restricted to the thermoplastic elastomer composi-  
3 tion specified in the earlier description of the "Elastomer Component"  
4 as the core (although these compositions are the most preferred) but  
5 may instead contemplate the use of any thermoplastic elastomer resin  
6 composition. The preferred resin composition comprises from 10 to 55  
7 wt % of the elastomer component, from 35 to 80 wt % of the EVA compo-  
8 nent, and from 2 to 25 wt % of the processing oil component.

#### 9 OPERATION

10 In practice, the process of the present invention may be  
11 carried out using an in-line operation wherein the extruder and  
12 orientation system (e.g., tenter) are arranged in tandem to form the  
13 film by casting or melt embossing followed by film orientation.  
14 Alternatively, these operations may be carried out separately.

15 In a preferred embodiment, the compounded resin containing  
16 the three main ingredients along with the other additives is intro-  
17 duced into an extruder and extruded into a web from a flat or coat-  
18 hanger type die and melt embossed through counter rotating chill roll  
19 and embossing rolls. The film thickness may vary from 50 to 400  
20 microns before orientation and from 10 to 200 microns after  
21 orientation. Preferably the film will have a final stabilized thick-  
22 ness of between 10 and 100 microns after orientation and annealing.  
23 The film is wound on a take up roll and transferred to tentering  
24 equipment or processed in line with the tenter.

25 The edges of the film are gripped in the tentering equipment  
26 and passed successively through (a) a preheat stage, (b) an expansion  
27 stage wherein the film is stretched laterally at an elevated tempera-  
28 ture, (c) an annealing stage and, finally, (d) a cooling stage where  
29 the stretched film is cooled to near ambient temperature. Once the  
30 restraining force is released, the film snaps back slightly but  
31 retains most of its stretched length. This film is wound on a take up  
32 roll, ready for transport or use.

33 The dimensionally stable film may be secured to a flexible  
34 substrate and heated causing it to shrink. Shrinkage commences at a  
35 few degrees above storage temperature, reaching maximum at some  
36 temperature above the orientation temperature.



804).  
1 In the embodiment for the coating of a thermoplastic elasto-  
2 mer, the operation may be the same as above except that in extrusion  
3 of the resin to form the film, a coextrusion die may be used to apply  
4 the thin coating on one or both sides of the thermoplastic elastomer  
5 core.

6 In either embodiment, the film produced has excellent shrink  
7 force properties and good antiblock properties.  
8

TABLE I  
FILM SAMPLE

Component	FILM SAMPLE			COMPARATIVE FILM SAMPLES		
	A	B	C	D	E	F
Elastomer <sup>1</sup>	22.6 wt %	27.0 wt %	39.4 wt %	39.4 wt %	22.6 wt %	27.0 wt %
EVA <sup>2</sup>	71.7 wt %	66.2 wt %	55.0 wt %	41.6 wt %	58.4 wt %	49.6 wt %
Process 0113	5.6 wt %	6.8 wt %	5.6 wt %	19.0 wt %	19.0 wt %	23.4 wt %
MI	3.25	2.63	2.16	2.66	6.6	10.3

- 1 Ethylene-propylene copolymer rubber marketed as Vistalon 3708 by Exxon Chemical Company.
- 2 LD-767 (28 wt % VA) sold by Exxon Chemical Company.
- 3 Arco Prime 350 sold by Arco Chemical Company.

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17

TABLE II

Sample	Test	Initial Gauge (microns)	Initial Length (cm)	Final Length (cm)	% Recovery (Actual Draw)	Calculated Shrink Force (grams)
A	Free	157.5	8.0	4.3	91.6	222
	Restrained	149.9	8.0	4.5	87.5	
B	Free	157.5	8.0	4.4	90.0	450
	Restrained	157.5	8.0	4.5	86.8	
C	Free	152.4	8.0	4.4	89.9	169
	Restrained	154.9	7.9	4.6	85.6	
D	Free	152.4	8.1	4.3	91.9	134
	Restrained	149.9	8.2	4.7	82.2	
E	Free	160.0	7.9	4.3	91.5	148
	Restrained	162.6	8.0	4.7	82.6	
F	Free	157.18	8.1	4.4	88.5	127
	Restrained	152.4	8.1	4.7	81.3	

TABLE III

Restraining Force (grams)	Strip Length after shrinkage (cm)						Shrink Force (grams)**	Area (cm <sup>2</sup> )	Shrink Stress g/cm <sup>2</sup>
	0	12	24	36	48	60			
Sample A*	49°C	8.08	8.33	9.62	8.89	9.08	91	.010	9,100
	65.5°C	5.83	6.26	6.98	7.73	8.38	73	.011	6,636
Sample D*	49°C	8.57	8.82	9.15	9.41	9.74	59	.014	4,214
	65.5°C	5.73	6.23	6.91	7.90	8.75	65	.016	4,063

\* three strip sample average

\*\* calculated

CLAIMS:

1. An oriented film ~~having a blend composition comprising~~  
from 10 to 40 weight percent of ~~an~~<sup>the</sup> olefinic elastomer, not more than  
12 weight percent of ~~a~~<sup>the</sup> normally liquid process oil, and from 50 to 80  
weight percent of ~~a~~<sup>the</sup> thermoplastic ethylene copolymer, ~~said film being~~  
*and in that the film is* stretch oriented in draw ratio of from 1.3:1 ~~and~~<sup>to</sup> 6:1. ~~and being~~

*which is* dimensionally stable, thermally unstable in the stretch oriented con-  
dition and contractible to a thermally stable and elastic condition by  
application of heat, *and which has a blend composition comprising an*  
*olefinic elastomer, a normally liquid process oil and a thermoplastic ethylene*  
*copolymer, characterized in that the blend comprises*

2. A film as defined in claim 1 wherein the thermoplastic  
ethylene copolymer is EVA, EAA or EMA and wherein the  
film has been stretch oriented in the transverse direction at a  
temperature not less than 37°C and not more than 5.6°C below the  
crystalline melting point of the copolymer and partially annealed in a  
stressed condition.

3. A film as defined in claim <sup>1</sup> wherein the blend composi-  
tion comprises from 15 to 30 weight percent of EPM or EPTM as  
olefinic elastomer, from 60 to 80 weight percent of EVA having  
a vinyl acetate content of 9 to 40 weight percent, and from 2 to 10  
weight percent of a normally liquid  
aromatic, naphthenic or paraffinic process oil.

4. A film as defined in claim 3 wherein the <sup>blend</sup> composition  
comprises from 20 to 30 weight percent of the olefinic elastomer, from  
65 to 75 weight percent of the EVA, and from 4 to 8 weight percent of  
the process ~~oil~~ oil.

5. → (insert from page 24)

6 5. A film as defined in any of claims 1 to <sup>5</sup>, wherein the film has been  
stretch oriented in the transverse direction at a draw ratio of  
from 2:1 to 4:1.

7~~6~~. A film as defined in any of claims 1 to <sup>6</sup>~~5~~, wherein <sup>which</sup> the ~~film~~ has a shrink stress of at least 5,000 g/cm<sup>2</sup> at the stretch orientation temperature.

14~~7~~.

A composite comprising

(a) a first layer comprising the film defined in any of claims 1 to ~~5~~; and

(b) a second layer of stretch oriented film adhered to said first layer and comprising a polymer or copolymer of ethylene having a Melt Index of at least 3.0, said second layer being no thicker than 7 microns in the stretched condition and comprising from 2 to 15 weight percent of the composite.

15~~8~~.

A composite as defined in claim <sup>14</sup>~~7~~ wherein said second layer is coextruded with said first layer.

16~~8~~.

A composite as defined in claim <sup>14 or 15</sup>~~7 or claim 8~~ wherein the second layer comprises LDPE having a Melt Index between 5 and 30.

*16 which comprises two of said second layers, one*

17~~8~~.

A composite as defined in claim ~~8~~ wherein a layer of LDPE ~~is~~ coextruded onto each side of said first layer.

11,

An oriented composite comprising

- (a) a layer of a thermoplastic elastomer film containing from 2 to 25 wt % of a process oil; and
- (b) a coating of a polymer or copolymer of ethylene coextruded with said first layer and having a Melt Index of between 5 and 30, said coating being less than 7 microns thick in the oriented condition and containing from 500 to 5,000 ppm of a particulate antiblock agent.

insert  
page 22

- 8 ~~12~~. A process for preparing a heat shrinkable <sup>oriented</sup> film ~~com-~~  
~~prising~~ as defined in claim 1 but where the oil content of the blend  
 composition is not more than 10 weight percent; which comprises  
 (a) extruding a ~~molten~~ blend <sup>in melt form</sup> comprising  
 (i) ~~from 10 to 40 weight percent of an elastomer;~~  
 (ii) ~~not more than 10 weight percent of a hydro-~~  
~~carbon oil; and~~  
 (iii) ~~from 50 to 80 weight percent of a thermo-~~  
~~plastic copolymer of ethylene;~~  
 (b) stretch orienting the film in the TD from 1.5 to 9  
 times its original length at a temperature not less  
 than 37°C and not more than 5.6°C below the  
 crystalline melting point of the ethylene  
 copolymer;  
 (c) partially annealing the stretched film; and  
 (d) cooling the film while maintaining stress on the  
 film.

9 ~~13~~, A process as defined in claim ~~12~~ <sup>8</sup> wherein the ethylene  
 copolymer is EVA, EAA, or EMA.

10 ~~14~~. A process as defined in claim ~~12~~ <sup>9</sup> wherein the annealing  
 step is carried out under stress and at a temperature between  
 ± 11.1°C of the orienting temperature.

11 ~~15~~. A process as defined in claim ~~12~~ <sup>10</sup> wherein the annealing  
 and cooling steps are carried out in part by permitting the film to  
 shrink in the TD by no more than 30% of the total stretch distance.

12 ~~16~~. A process as defined in any of claims ~~12~~ <sup>8</sup> to ~~15~~ <sup>11</sup> wherein the stretch  
 orientation stretches the film by from 2 to 4 times its original  
 length in the TD.

- 22 -

13 ~~14~~.

comprises

according to claim 8 wherein the  
A process for preparing a heat shrinkable film which  
composition comprises

stretch orienting <sup>ed to</sup> a film having a thickness of between  
50 and 400 microns and a composition of

- (i) from 15 to 30 weight percent of an EPM or EPDM elastomer <sup>(as the elastomer component)</sup>
- (ii) from 60 to 80 weight percent of an ethylene vinyl acetate copolymer (EVA) having a vinyl acetate content of about 15 to 35 weight percent <sup>(as the ethylene copolymer component)</sup>; and
- (iii) from 2 to 10 weight percent of a normally liquid hydrocarbon process oil <sup>(as the oil component)</sup>, and wherein (a) <sup>the film is</sup>

by drawing the film in the transverse direction from 1.5 to 9 times its original length at a temperature of from 37°C to below the crystalline melting point of the EVA;

- (b) <sup>the film is</sup> partially annealing <sup>ed</sup> the film at an annealing temperature of + 22.2°C of the stretch temperature but less than the crystalline melting point of the EVA while maintaining a stress on the film; and
- (c) <sup>is cooled</sup> cooling the film to ambient temperature while maintaining a stress on the film during at least a portion of the step.

14-17 →

18.

A process for manufacturing a heat shrinkable film composite having improved antiblock properties which comprises.

- (a) preparing a film of from 50 to 400 microns thickness from a thermoplastic elastomer resin composition comprising an elastomer, a thermoplastic polyolefin and a processing oil;



- (b) coextruding with said thermoplastic elastomer film a layer of an ethylene polymer or copolymer to form a composite, said polymer or copolymer having a Melt Index of at least 3.0, and constituting from 2 to 15 wt % of the composite and being no thicker than 25 microns;
- (c) stretch orienting the composite at a temperature not less than 37°C and not greater than 5.6°C below the crystalline melting point of the polyolefin by a draw ratio of from 1.5:1 and 9:1 such that the layer thickness is no greater than 7 microns; and
- (d) cooling the stretched composite to form a dimensionally stable elastomeric composite which said composite being heat shrinkable at temperatures above the cooling temperatures.

18 ~~18~~

A composite comprising

- (a) a layer of flexible substantially inelastic material; and
- (b) a layer of film as defined in any of claims 1 to <sup>7</sup>~~8~~ secured to the layer of flexible substantially inelastic material whereby application of heat contracts both the film and the layer of flexible, substantially inelastic material.

19 ~~20~~

A process for preparing an elasticized composite <sup>according to claim 18</sup> material which comprises

- (a) stretch orienting a film having a thickness of from 50 and 400 microns and a composition of
  - (i) from 15 to 30 weight percent of an EPM or EPDM elastomer;

- (ii) from 60 to 80 weight percent of an ethylene vinyl acetate copolymer (EVA) having a vinyl acetate content of from 9 to 40 weight percent; and
  - (iii) from 2 to 10 weight percent of a normally liquid hydrocarbon process oil;
- by drawing the film in the transverse direction from 1.5 to 9 times its original length at a temperature not less than  $37^{\circ}\text{C}$  and below the crystalline melting point of the EVA;
- (b) annealing the film at an annealing temperature of  $\pm 11.1^{\circ}\text{C}$  of the orientation temperature while maintaining a stress on the film;
  - (c) cooling the film to room temperature;
  - (d) securing a strip of the film to a layer of flexible, substantially inelastic material at longitudinally spaced locations along the film to form a composite;
  - (e) heating the composite to a temperature in excess of  $37^{\circ}\text{C}$  to within  $\pm 11.1^{\circ}\text{C}$  of the orienting temperature whereby the film and the layer of flexible, substantially inelastic material contract to an elastic heat stable condition.

20.21. The process of claim 19 wherein the orienting temperature and annealing temperature are between  $37^{\circ}\text{C}$  and  $71^{\circ}\text{C}$ .

5. 22. The film of claim 3 wherein the EVA has a VA content of from 15 <sup>to</sup> 35 wt %.

insert page 19